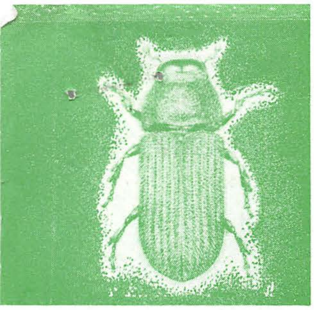

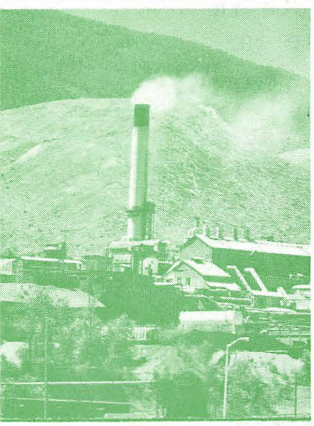

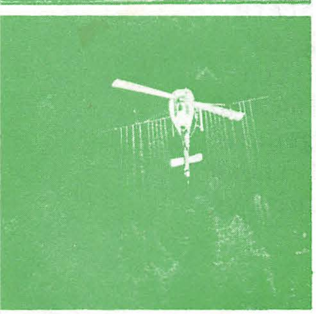

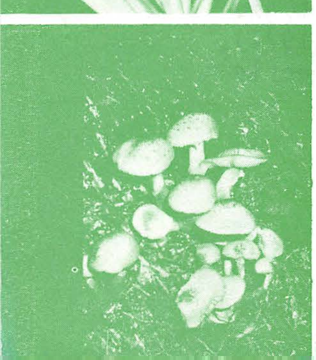

FOREST INSECT & DISEASE MANAGEMENT

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MOUNTAIN PINE BEETLE INFESTATION POTENTIAL FOR THE PLAINS RANGER DISTRICT, LOLO NATIONAL FOREST

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ABSTRACT

This report contains an overview of the present mountain pine beetle infestation in lodgepole pine stands on Federal, State, and private lands on the Plains Ranger District. Particular emphasis is placed on the potential for beetle mortality in the Thompson River drainage where recent ground surveys show more than 21 trees per acre were killed in 1978. Management alternatives which can lessen the severity, or reduce the possibilities, of future infestations are discussed.

INTRODUCTION

Much has been written describing the severity and extent of mountain pine beetle infestations in the West. This is but one in a series of periodic outbreaks which have occurred in lodgepole pine stands. Due to man's recent intervention in the ecology of lodgepole pine, however, probably no previous decade of recorded infestations has been as extensive nor as locally devastating. The most current group of infestations in Montana began and developed to epidemic proportions on the Gallatin National Forest in 1969. Populations were increasing concurrently with those which swept through Yellowstone National Park beginning in 1966. This outbreak was augmented by migrating beetles from the Targhee National Forest in southeastern Idaho where populations began increasing in the late 1950's. Through 1977, over 500 MMBF of merchantable timber was killed on the

Gallatin National Forest. Many of these infestations, having existed for nearly a decade, are now declining, or will begin to decline as susceptible host material is depleted. This extended period of tree killing has had ruinous effects on timber inventories.

A multiphase damage assessment survey conducted on the Targhee National Forest in 1977 showed over 21 million standing dead trees killed by the mountain pine beetle on approximately 400,000 acres (Klein, Bennett, and Young 1979). On the Island Park Ranger District, Targhee National Forest, which is approximately 30 miles south of West Yellowstone, MT, a trend study revealed 69.5 percent of the lodgepole pine 6 inches in diameter had been killed between 1973 and 1978 (Gibson and Bennett 1978). Aerial and ground surveys recently completed in the Northern Region indicate in excess of 42 million trees were killed by the mountain pine beetle in 1978 (McGregor, Gibson, and Bennett 1979).

We are currently analyzing data to determine the effect of this past winter's severely cold temperatures on overwintering mountain pine beetle brood. Preliminary information suggests that in some areas, substantial mortality may have occurred. Without this ameliorating factor, we would expect that trees attacked in 1979 could double those killed in 1978.

Of the more than 42 million trees killed in 1978, approximately 45 percent were confined to the Yellowstone, Gallatin, Beaverhead infestations. The remainder were located on the Flathead, Kootenai, and Lolo National Forests and in Glacier National Park in the northern part of the State. Infestations in the northern half of the Region began developing to epidemic proportions in 1972. The Glacier National Park infestation increased rapidly from 1,180 acres infested in 1972 to more than 164,000 acres in 1978. In 1975, the epidemic spread into susceptible lodgepole stands on the Flathead National Forest. The infestation on the Flathead National Forest now covers approximately 78,000 acres and ground surveys indicate more than 79 trees per acre were killed last year.

Similar histories can be written of the Kootenai and Lolo infestations. This report will concentrate on the infestation potential on the Lolo National Forest with emphasis on the Plains Ranger District. Mountain pine beetle populations reached epidemic proportions on 700 acres in the Lazier and Meadow Creek drainages of the Plains Ranger District in 1972 (McGregor, et al, 1975). Between 1972 and 1974 approximately 118,000 trees were killed as the infestation spread over 5,000 acres on lands which encompassed Federal (Lolo National Forest), State (Thompson River State Forest), and private holdings. Subsequent infested acres were determined to be: 1976 - 22,987; 1977 - 10,599; 1978 - 24,561. In 1976, Northern Region entomologists surveyed five stands in the general vicinity of Bend Campground on the Thompson River. (McGregor, et al, 1977). Using a hazard rating system developed by Amman, et al. (1977), each stand was given a hazard classification for mountain pine beetle

potential. Three of the five stands were found to be in the "high risk" category. The remaining two were rated as "moderate". Basing our opinion on available timber type maps, and lacking more accurate ground inventory data, we believe many high hazard stands remain on the Thompson River drainage and that beetle infestation will continue to build in the next 3 to 5 years. We have just completed the collection and analyzing of beetle trend data on 97 variable (BAF 10) plots from nine locations on mixed ownership within the Thompson River drainage (Figure 1). The following describes these results and subsequent management implications.

SURVEY METHODS

To supplement aerial surveys, we routinely establish ground plots in currently infested stands following beetle flight each year. These surveys obtain accurate data concerning trees attacked during the current year, previous year's mortality, and remaining green stand. Buildup ratios (a comparison of current year to previous year attacks), used for predicting future mortality, are also determined.

Ten variable (BAF 10) plots were established, where practicable, at a 5- by 5-chain spacing in each survey area. On each plot "in" trees were determined using a relaskop or a 10-factor prism. Trees were recorded according to the following designations: green, current attack, previous year attack, older dead (snag), strip attack, unsuccessful attack (pitchout), or other mortality. All species were tallied by diameter. Heights of the first two trees of each species were recorded for volume estimations. In addition, regeneration data were accumulated from 1/300-acre plots taken at each plot center. Data were analyzed using the computer program INDIDS (Bousfield 1977).

The number of survey areas established in a given infestation depend on infestation level, available personnel, and time. In addition to the nine areas surveyed in the Thompson River drainage, adjacent areas on the Flathead National Forest (15 areas), Glacier National Park (8 areas), and the Kootenai National Forest (13 areas) were also cruised (Gibson and McGregor, 1979).

To supplement this survey information, data were obtained from 19 demonstration cutting blocks on the northwestern portion of Plains Ranger District. These blocks range in size from 9 to 22 acres, and are concentrated near Fishtrap Lake. Within each area, twenty 1/4-acre fixed plots were established from which only tree mortality from the mountain pine beetle data were taken, i.e., 1978 attacks and 1977 attacks. Green stand data were collected from ten 1/20-acre fixed plots per block. From these we obtained the phloem thickness/diameter distribution for the residual green lodgepole pine.

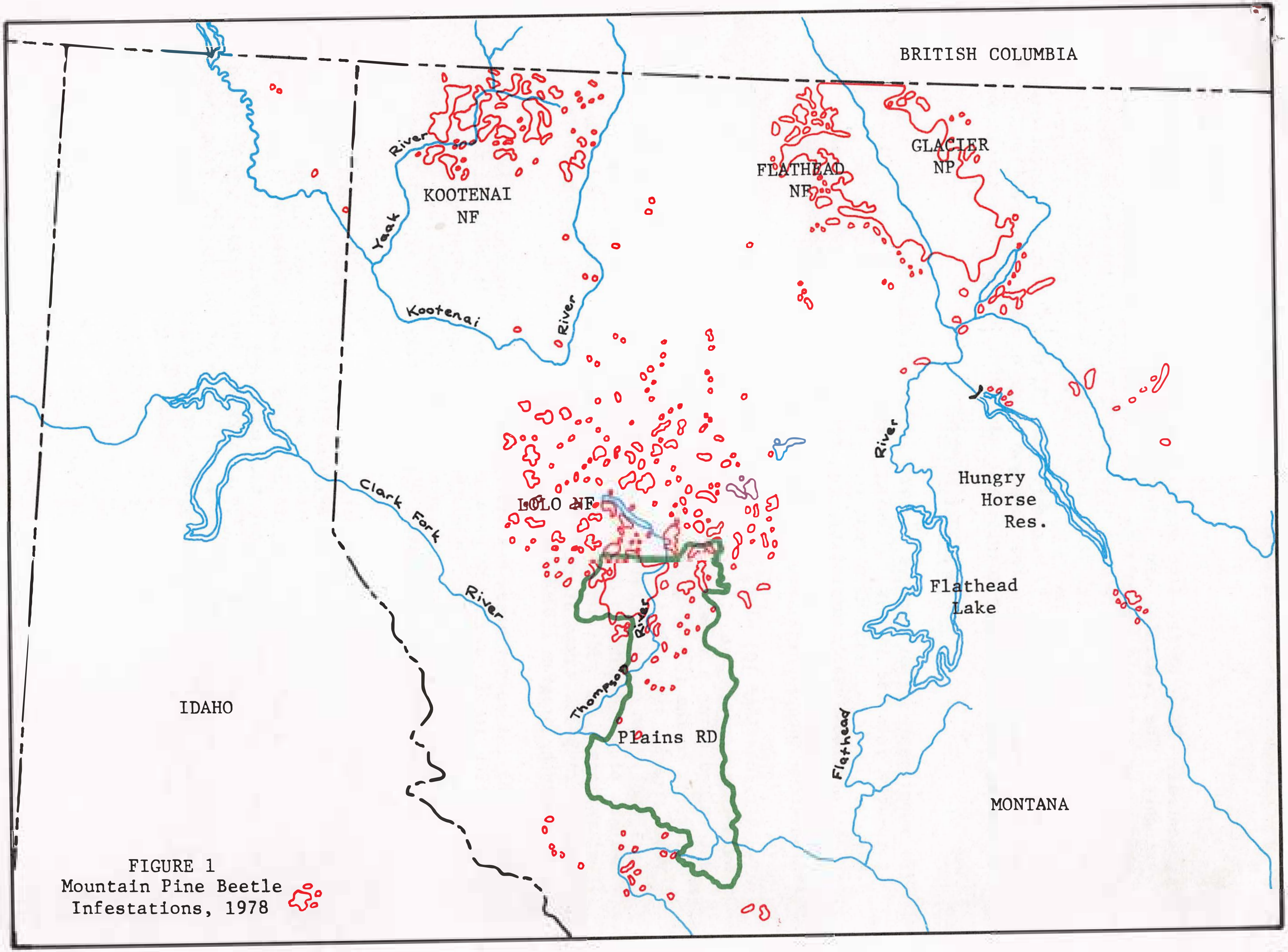
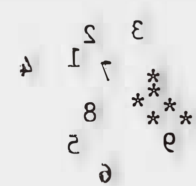
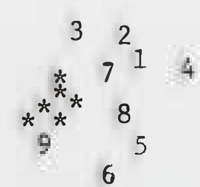


FIGURE 1
Mountain Pine Beetle
Infestations, 1978



Survey Areas 1,2,... Demonstration Blocks *



Survey Areas 1,2,... Demonstration Blocks *

RESULTS

Survey results from the Thompson River trend plots are contained in tables 1 and 2. Attacked trees for 1978 ranged from 1.5 to 70 per acre, average 21.5. Results from the demonstration blocks show an average of 13.9 trees per acre attacked in 1978 (Table 3).

Table 1.--Mountain pine beetle mortality. Data based on 97 variable (BAF 10) plots.

Plot	Green	1978 attack	1978 strip	1977 attack	Snag	P.O.[1/]	Total mortality
		(Trees per Acre)					
1. Thompson River	369.4	1.5	-	1.8	1.9	1.5	5.2
2. L. Thompson Lake	227.5	8.9	-	0.8	1.6	9.0	11.3
3. Boiling Spr. Creek	361.0	11.2	7.7	14.3	15.7	15.4	41.2
4. Murr Creek	428.1	15.0	2.5	6.5	8.4	8.9	29.9
5. Indian Prairie	80.2	30.0	6.7	29.5	43.3	3.8	102.8
6. Richards Peak	146.3	23.0	-	25.6	7.8	1.0	56.4
7. Twin Lakes Creek	876.1	12.8	19.0	7.3	2.3	18.4	22.4
8. Bend Campground	424.9	70.0	-	10.1	27.1	19.8	107.2
9. Fishtrap Creek	234.6	20.8	-	57.1	45.1	-	123.0
Plot Totals	349.8	21.5	4.0	17.0	17.0	8.6	55.5

Buildup Ratio x/x/ = 21.5/17.0 = 1.26:1

Predicted Mortality (1979) = bx = 27.1 trees/acre

1/ P.O. = "pitch outs", i.e. those trees that resisted attack.

Table 2.--Green stand component. Data based on 97 variable (BAF 10) plots.

Plot	LPP	PP	L	GF	AF	S	DF
		(Trees per acre)					
Thompson River							
0-4.9	360.0	-	-	60.0	-	-	780.0
5-11.9	8.7	-	12.5	-	3.8	1.7	42.6
12+	2.2	0.2	4.9	0.6	-	3.5	19.3
Total	370.9	0.2	17.4	60.6	3.8	5.2	841.2
Lower Thompson Lake							
0-4.9	180.0	-	30.0	-	-	-	540.0
5-11.9	54.6	1.7	18.8	-	-	-	52.9
12+	1.9	3.5	7.1	-	-	-	23.3
Total	236.5	5.2	55.9	-	-	-	616.2
Boiling Spring Creek							
0-4.9	210.0	-	-	-	-	60.0	150.0
5-11.9	170.6	-	44.3	-	-	-	21.9
12+	3.5	0.7	10.1	-	-	-	1.2
Total	384.1	0.7	54.4	-	-	60.0	173.1
Murr Creek							
0-4.9	90.0	-	-	-	-	15.0	15.0
5-11.9	347.1	-	-	-	-	3.3	-
12+	2.4	-	-	-	-	0.2	-
Total	439.5	-	-	-	-	18.5	15.0
Indian Prairie							
0-4.9	-	-	60.0	90.0	-	-	690.0
5-11.9	90.7	4.7	30.6	-	-	-	64.5
12+	-	1.2	7.0	-	-	-	1.9
Total	90.7	5.9	97.6	90.0	-	-	756.4
Richards Peak							
0-4.9	90.0	-	-	60.0	-	-	720.0
5-11.9	55.2	10.7	-	-	-	-	80.8
12+	2.1	4.0	1.5	-	-	-	13.7
Total	147.3	14.7	1.5	60.0	-	-	814.5

Abbreviations:

LPP = Lodgepole pine
PP = Ponderosa pine
L = Larch
GF = Grand fir
AF = Subalpine fir
S = Spruce
DF = Douglas-fir

Table 2.--Green stand component. Data based on 97 variable (BAF 10) plots. Continued

Plot	LPP	PP	L	GD	AF	S	DF
Twin Lakes Creek							
0-4.9	771.4	42.9	-	-	-	-	-
5-11.9	137.8	4.0	-	-	-	-	8.4
12+	4.3	6.5	-	-	-	-	-
Total	913.5	53.4	-	-	-	-	8.4
Bend Campground							
0-4.9	330.0	-	-	30.0	-	-	270.0
5-11.9	114.7	-	-	-	-	2.1	3.3
12+	-	0.6	0.2	-	-	0.7	4.8
Total	444.7	0.6	0.2	30.0	-	2.8	278.1
Fishtrap Creek							
0-4.9	210.0	-	-		30.0	-	120.0
5-11.9	24.6	3.0	2.1		3.6	2.3	22.7
12+	-	-	-		1.3	-	1.4
Total	234.6	3.0	2.1		34.9	2.3	144.1
Plot Totals							
0-4.9	260.2	4.7	10.0	26.7	3.3	8.3	365.0
5-11.9	111.6	2.7	12.0	-	0.8	1.0	33.0
12+1	1.8	1.9	3.4	0.1	0.1	10.5	7.3
Total	373.6	9.3	25.4	26.8	4.2	19.8	415.3

Table 3.--Mountain pine beetle mortality and remaining green stand in 21 demonstration blocks.

Block No.	78 attacks (per acre)	77 attacks (per acre)	Green stand (%) trees ≥5" dbh	
1	0.24	0.08	57.4 Lpp	19.7 Larch
4	4.20	1.00	89.2 Lpp	4.2 Larch
4A	3.60	-	80.9 Lpp	11.9 Larch
5	1.60	1.40	82.1 Lpp	11.5 Larch
6	1.40	0.80	99.1 Lpp	0.3 Larch
7	1.60	-	100 Lpp	
8	0.20	0.40	95.0 Lpp	2.4 DF
9	4.80	1.60	95.7 Lpp	2.5 DF
14	89.00	22.00	Data not available	
15	127.20	67.80	100 Lpp	
16	40.20	13.00	47.1 Lpp	31.4 DF
17	2.60	-	94.6 Lpp	3.4 DF
18	5.80	1.00	56.0 Lpp	26.3 DF
19	-	-	Data not available	
21	1.60	0.20	84.1 Lpp	7.4 Larch
27	8.40	63.00	87.4 Lpp	9.4 DF
29	-	-	66.2 Lpp	14.1 DF
30	0.40	0.20	56.3 Lpp	39.9 DF
31	0.60	1.00	74.1 Lpp	15.2 DF
33	-	-	93.8 Lpp	3.9 DF
34	0.20	1.40	94.5 Lpp	2.7 DF
Total	13.98	8.33		

Buildup ratio x/x_1 = 13.98/8.33 = 1.68:1.

Predicted mortality (1979) = bx = 23.49 trees/acre.

DISCUSSION

Baker (1968) developed a method for predicting future mortality. This mortality is determined using a buildup ratio of current year's to previous year's mortality. His formula for predicted mortality is: $y' = y + bx$, where:

y' = predicted mortality through next year
y = trees killed through current year
b = buildup ratio (x/x_1)
x = trees killed current year.
x_1 = trees killed previous year.
(Note: All figures are in trees per acre).

Buildup ratios and predicted tree mortality are given for both the Thompson River trend plot area and the Demonstration Block area following tables 1 and 3. In both cases, tree mortality in 1979 is expected to increase substantially.

One possible ameliorating factor is the severely cold temperatures experienced during December 1978 and January 1979. Schmid and Frye (1977) cite evidences showing spruce beetle mortality has been high when subjected to temperatures as low as -40°F for 5 consecutive days or more. Temperatures of -31° to -40°F during December 1932 and January 1933 caused high mortality of mountain pine beetle brood, and a marked reduction in number of trees killed in 1933 on the Beaverhead National Forest. 1/ The effects of cold temperatures on mountain pine beetle populations experienced this winter will not be fully known until after this year's attack period. Preliminary data accumulated this spring shows larval mortality varies considerably between areas. Data collected from trees near McGregor Lake showed only 10 percent overwintering mortality. In other portions of the State, larval mortality ranges from 80 to 100 percent and in those areas a reduction in beetle population and number of trees attacked/acre is predicted. If, however, the McGregor Lake sample is representative of the Thompson River area, 1979 beetle populations may be affected little, if at all. The best we can probably expect is a 2- to 3-year respite. As long as susceptible lodgepole pine stnds remain, beetle populations will undoubtedly recover.

Safranyik 2/ has identified six criteria for determining the likelihood of beetle immigration into uninfested areas:

1/ Unpublished data, Region 1 files.
2/ Safranyik, L. 1979. Personal communication.

1. Historic evidence of beetle activity in surrounding areas.

2. Recent beetle activity, particularly within the past 3-5 years. Determination of building or declining populations.

3. Tree age, size, and species distribution within the uninfested area. Are trees of a susceptible age and size class and does the stand have a high percentage of host species?

4. Large contiguous areas of high-hazard, uninfested trees.

5. Major outbreaks near the uninfested area. There is much evidence to show that beetle populations do migrate into, as well as develop in, a given stand.

6. Relationship of elevation and latitude.

Many of these same criteria have been incorporated into a hazard rating system developed by Amman, et al. (1977). Their criteria for a high-hazard lodgepole stand are:

1. Average stand age >80 years.

2. Average stand diameter >8 inches in dbh.

3. Elevation <6,000 feet (at 48^{O}N latitude).

After measuring several lodgepole pine stands in Colorado, Cole and Cahill (1976) stated that epidemics are not as likely to occur in stands where less than 20 percent of the trees are >8 inches dbh and contain phloem 0.11 inch thick or thicker. They concluded that the distribution of phloem thickness over diameter classes can be an effective measurement for evaluating infestation potential in a logdepole pine stand. A review of the phloem thickness/diameter class distribution for surveyed areas on the Plains RD are found in tables 4 and 5. These would indicate a high percentage of the remaining green stand could sustain a mountain pine beetle infestation (Table 6).

MANAGEMENT ALTERNATIVES

Within the past several years, much valuable information has been obtained concerning manipulation of mountain pine beetle populations through appropriate stand management. Cole (1977) and Amman, et al. (1977) have stated that infested stands and high-risk stands can be managed in several ways depending upon land use objectives and stand composition. Where extensive stands contain large-diameter and older-age trees (high risk), they can be broken up by small organized clearcuts. This will help eliminate those stands which are conducive to large population buildups of the beetle. Where smaller stands are, or approach, high-risk, they should be completely removed.

Table 4.--Phloem thickness/diameter distribution for trees on Thompson River trend plots (phloem thickness averaged from 1978 attacked and unattacked "in" trees on 97 variable plots)1/

Dbh	Thompson River		Lower Thompson Lake		Big Spring Creek		Murr Creek		Indian Prairie		Richards Peak		Twin Lakes	
	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green
5	--	--	--	0.037	--	0.030	--	0.049	--	0.061	--	0.077	--	0.037
6	--	0.050	0.060	.072	--	.078	--	.060	0.035	.080	--	.065	--	.072
7	--	--	.075	.087	--	.072	0.085	.070	.070	.063	--	.070	--	.056
8	--	--	.067	--	0.030	.031	.065	.074	.070	.075	0.055	--	0.075	.073
9	--	--	--	.082	--	.084	--	.079	--	.090	--	--	--	--
10	--	--	--	.045	.062	.075	.082	.083	.082	--	.090	.070	--	.050
11	0.050	.102	--	--	.075	.080	.067	.068	--	--	.087	.075	--	.067
12	--	.080	--	--	.070	.035	.050	.076	--	--	--	.035	--	.050
13	--	--	--	--	--	.087	--	--	--	--	--	.082	--	.070
14	--	.110	--	.045	--	--	--	.140	--	--	--	--	--	.075
15	--	--	--	.082	--	--	--	--	--	--	--	--	--	--

1/ Phloem thickness data not available from Bend Campground and Fishtrap Creek plots.

Table 5.--Phloem thickness/diameter distribution for trees on Plains demonstration blocks (phloem thickness averaged from 1978 attacked and unattacked trees in 380 ¼-acre fixed plots)[1]

Dbh	1		4		4A		5		6		7		8		9		15		16	
	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green
5	—	0.040	—	0.050	—	0.050	—	0.040	—	0.050	—	0.050	—	0.060	—	0.050	0.050	0.050	0.040	0.070
6	0.060	0.040	—	.050	—	.050	—	.050	—	.050	0.080	.060	0.070	.070	0.040	.050	.050	.070	.060	.070
7	—	.050	—	.060	0.070	.060	—	.060	0.030	.060	.030	.070	—	.080	.050	.060	.060	.070	.050	.050
8	.060	.060	—	.050	.060	.060	0.070	.070	.060	.070	.090	.080	—	.080	.050	.060	.070	—	.060	.030
9	.050	.060	0.080	.070	.060	.070	.090	.060	.080	.070	.090	.100	—	.090	.070	.080	.070	—	.060	.050
10	—	.060	.070	.070	.070	.070	—	.070	.090	.080	—	.090	—	.090	.070	.080	.070	.070	.060	.060
11	.030	.050	.060	.070	.050	.070	.090	.070	—	.080	.100	.090	—	—	.070	.080	.090	—	.060	.060
12	.060	.050	.100	.090	.050	.070	—	—	—	.100	—	.090	—	.070	.070	.090	.080	—	.060	.070
13	—	—	.090	.090	—	.090	.110	—	—	—	.080	.060	—	—	—	.080	.060	—	.070	.080
14	—	.060	.100	—	—	.070	—	—	—	—	—	.080	—	—	—	—	—	—	.070	.050
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.060	.050
16	—	—	—	—	—	—	—	—	—	—	—	.110	—	—	—	—	—	—	.080	.090
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	.070	—

Dbh	17		18		21		27		29		30		31		33		34	
	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green	Attacked	Green
5	0.040	0.050	—	0.040	—	0.030	0.030	0.030	—	0.050	—	0.050	—	0.040	—	0.050	—	0.050
6	.040	.050	—	.060	—	.050	.050	.050	—	.050	—	.050	—	.040	—	.060	—	.050
7	.060	.060	—	.070	—	.050	.050	.050	—	.060	0.030	.050	0.050	.050	—	.060	—	.060
8	—	.060	0.050	.070	—	.060	.060	.060	—	.070	—	.060	—	.060	—	.060	—	.070
9	.120	.070	.070	.070	—	.060	.060	.070	—	.080	.090	.080	—	.070	—	.070	0.100	.070
10	.070	.070	.080	.070	—	.070	.070	.060	—	.090	—	.080	—	.060	—	.120	—	.070
11	—	.070	.070	.070	0.060	.070	.040	—	—	.080	—	.080	.070	.080	—	.090	—	.070
12	—	.110	.100	.070	.070	.080	.090	—	—	.090	—	.080	—	.100	—	—	—	.070
13	—	—	.080	.050	.050	.080	—	—	—	.070	—	—	—	.060	—	—	—	—
14	—	—	.090	.140	.050	.070	—	—	—	.100	—	.100	—	.110	—	—	—	—
15	—	—	—	—	—	.070	—	—	—	—	—	.090	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1/ Phloem thickness data for blocks 14 and 19 not available.

Table 6.--Current mortality, residual green stand, and predicted mortality of lodgepole pine 9 inches dbh, Plains RD, Lolo NF

Blocks/Plots	Percent current mortality ≥9" dbh	Percent residual green LPP ≥9" dbh	Percent predicted mortality LPP ≥9" dbh
1	12	38	33[1/]
4	19	51	41
4A	19	51	41
5	28	19	13
6	7	41	38
7	7	32	30
8	0	18	18
9	22	43	33
15	98	2	0
16	76	74	17
17	12	26	23
18	36	41	26
21	9	54	49
27	71	11	3
29	0	53	53
30	1	62	61
31	4	43	41
33	0	11	11
34	2	37	36
Thompson River	16	83	77
Lower Thompson Lake	0	50	50
Big Spring Creek	14	33	32
Murr Creek	10	30	27
Indian Prairie	50	10	5
Richards Peak	30	46	32
Twin Lakes	0	32	32

1/ Predictions based on unpublished research data using phloem thickness/average diameter relationships. Personal communication, W. E. Cole, 1979.

Cole (1977) has summarized feasible silvicultural practices for stands where composition is pure lodgepole and form is even-aged:

1. Stocking control in young stands.

2. Organized clearcutting in blocks to create age, size, and species mosaics from mature stands.

3. Salvage or partial cuts.

4. Salvage cutting to reduce mortality in stands under attack.

Amman (1976) stated, "Because the beetle concentrates heavily on trees of large diameter, continuous lodgepole forests at low elevations could be broken up into small blocks of different age and size classes, thereby reducing the area likely to be infested at any one time."

In uneven-aged pure lodgepole pine and mixed species stands, the preventive practices mentioned for pure, even-aged lodgepole pine stands are also feasible (Cole 1978). In <u>mature</u> mixed species stands with large lodgepole pine in the overstory, block clearcutting is recommended as a preventive to develop a mosaic pattern. If already attacked, mortality can be reduced by salvage cutting. Selective cutting to remove overstory lodgepole pine is recommended provided the residual trees are the desired species, age, and stocking level. If <u>immature</u>, such stands are candidates for stocking control, with species discrimination possible while reducing stand density in mixed species stands.

Discrimination against lodgepole pine is possible in older mixed stands through partial cuts in which only the most susceptible lodgepole pine portion of the main stand is removed (Cole 1977).

Partial cutting has been shown an effective treatment to reduce potential mortality in susceptible stands (Hamel and McGregor 1976; Cole and Cahill 1976; Hamel 1977).

Cautions have been issued, however, for the use of partial cuts. Where timber values are primary, partial cuts for beetle management may only be appropriate where a small proportion of the trees are high-risk lodgepole and where enough residual trees remain to maintain productivity (Amman 1976). Alexander (1975) has further cautioned that lodgepole stands partially opened may be more susceptible to windthrow, dwarf mistletoe, and logging damage. He also states that from a silvicultural viewpoint, partial cutting practices are the only options managers have where (1) multiple-use considerations preclude clearcutting, (2) combinations of cleared openings and high forest are required to meet various forest management uses, and (3) regeneration of the stand is difficult after clearcutting.

Data (unpublished) from the Lolo National Forest shows that selective cutting--removing some large as well as small diameter trees--has prevented and reduced beetle attack along visual areas such as roads, streams, etc. This will also lessen the siltation impact to stream channels which could be created by clearcutting. Partial cutting, whether selectively leaving large and small diameter lodgepole pine, or a straight commercial thinning based on tree diameter regardless of crown, has prevented and/or reduced incidence of beetle attack in stands on the Plains Ranger District, Lolo National Forest.

Finally, partial cutting can be applied as a last resort to after-the-fact salvage of beetle-killed trees. An increased utilization of sound material and a degree of direct control of beetle populations by removing beetle-infested trees would buy time to accomplish preferred block cutting (McGregor, et al. 1978).

One additional management alternative exists for those stands where single-tree esthetic values are primary. In campgrounds, summer home areas, or around administrative sites, high-value trees can be successfully protected from mountain pine beetle attack through the use of preventive sprays. An application of Sevimol-4®, a water-soluble mixture of carbaryl insecticide in a molasses carrier, prior to beetle flight has proven to be a safe, economical, and highly efficient means of protecting individual trees (Gibson 1978).

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